Aug. 9, 1938. R. L. KIRK 2,126,333

INTERLOCK SYSTEM FOR DOORS

Filed March 17, 1934 5 Sheets-Sheet 1

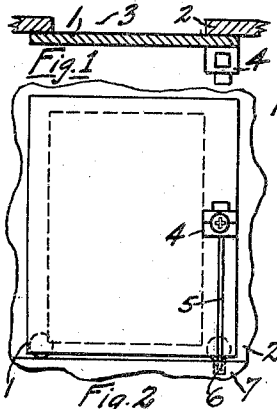


Fig. 1

Fig. 2

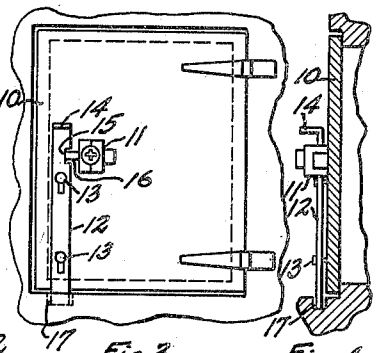


Fig. 3

Fig. 4

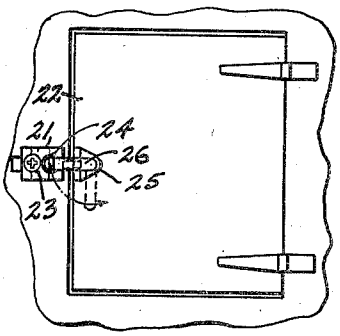


Fig. 5

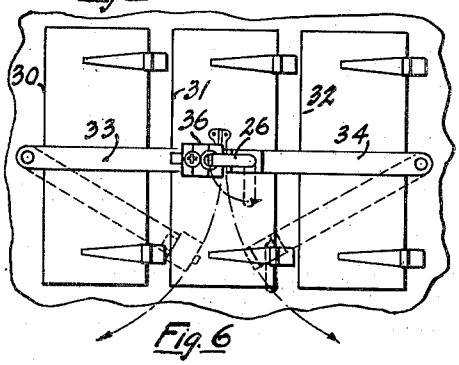


Fig. 6

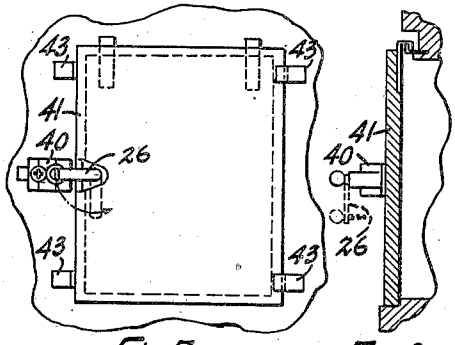


Fig. 7

Fig. 8

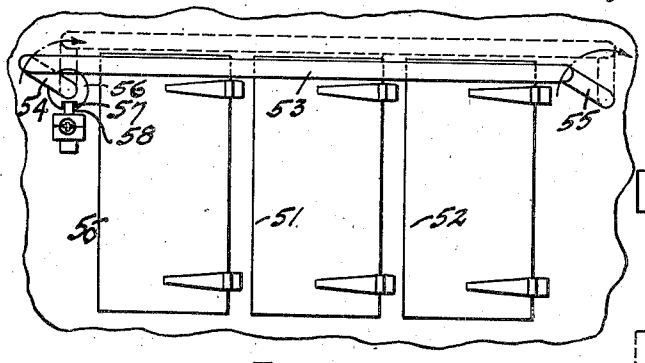


Fig. 9

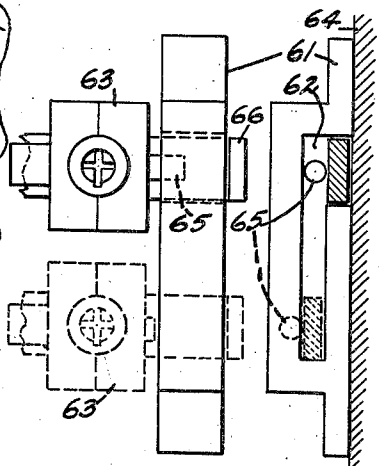


Fig. 11

Fig. 12

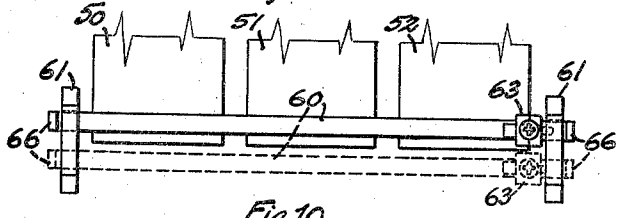


Fig. 10

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INTERLOCK SYSTEM FOR DOORS

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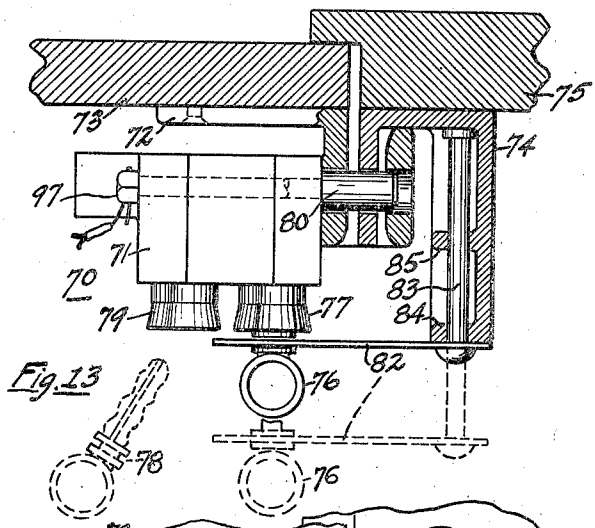


Fig. 13

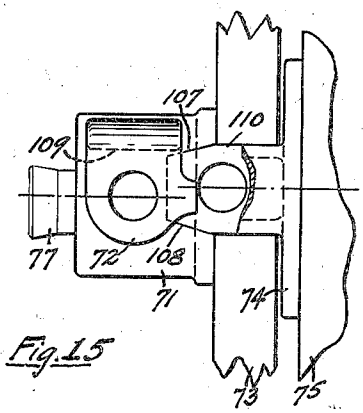


Fig. 15

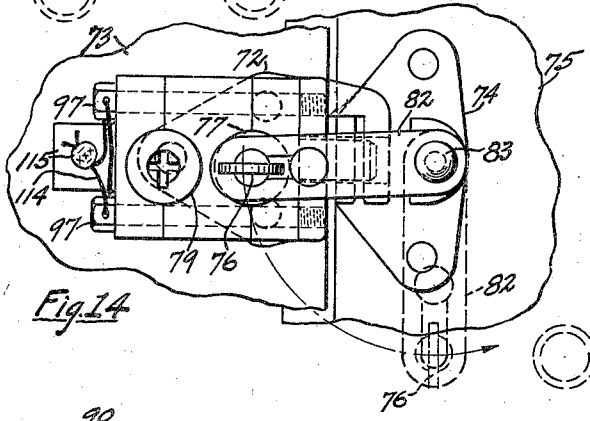


Fig. 14

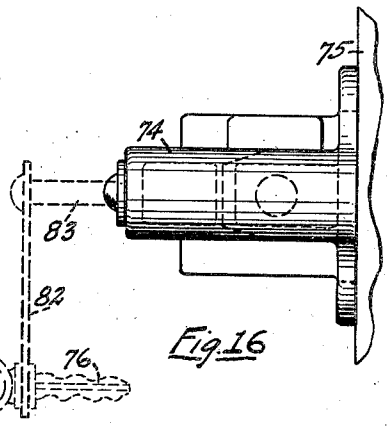


Fig. 16

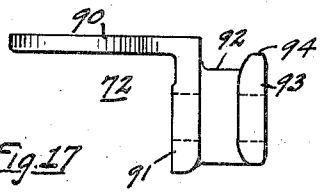


Fig. 17

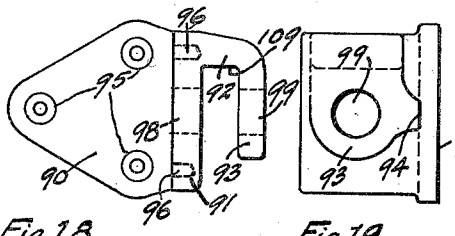


Fig. 18

Fig. 19

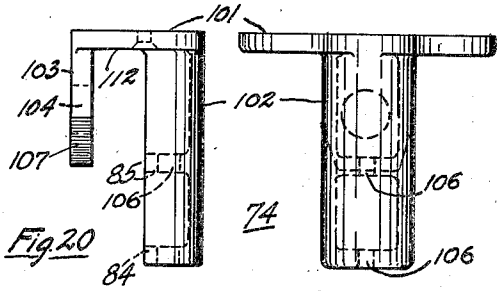


Fig. 20

Fig. 22

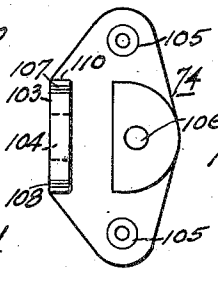


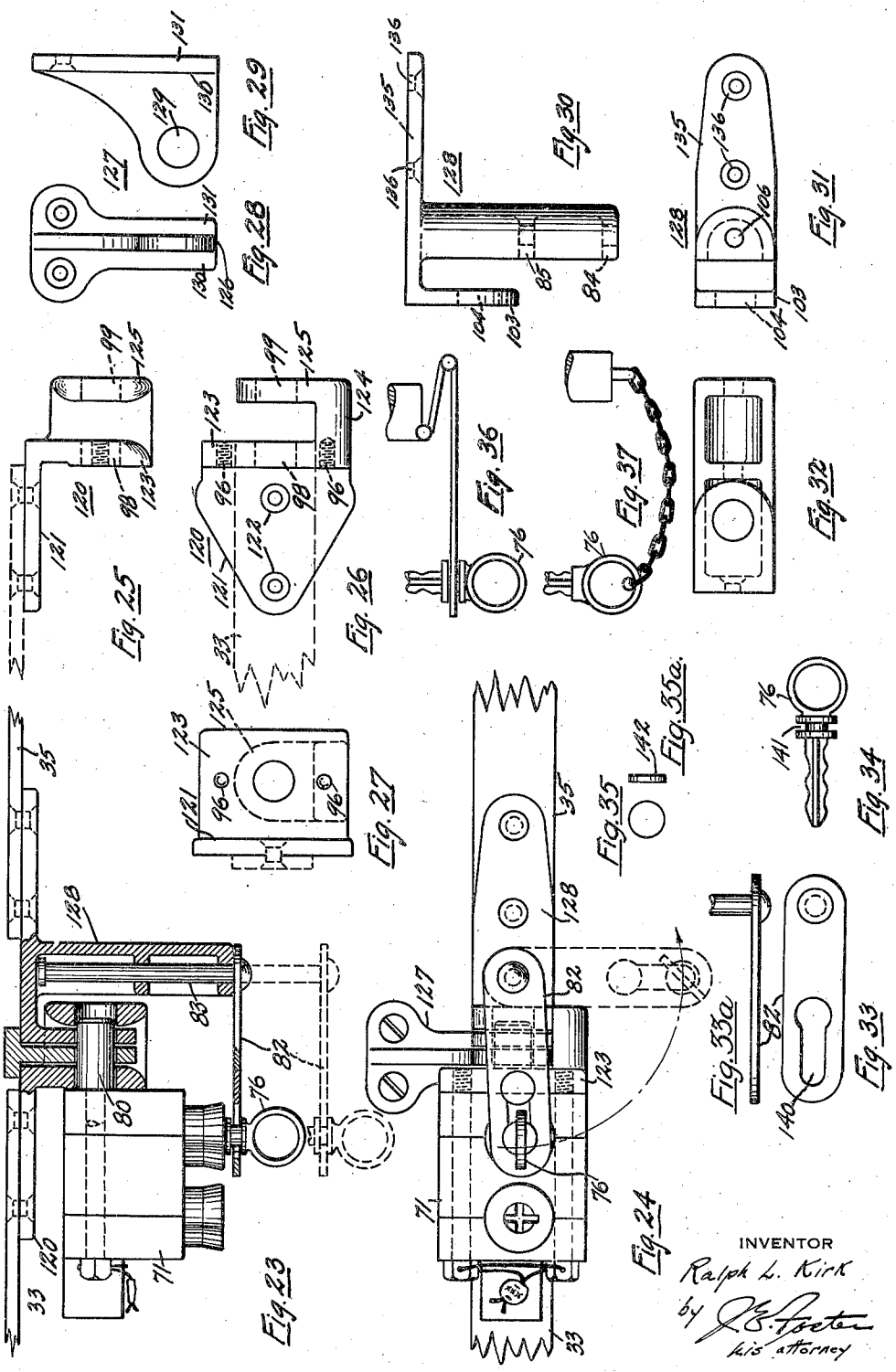
Fig. 21

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INTERLOCK SYSTEM FOR DOORS

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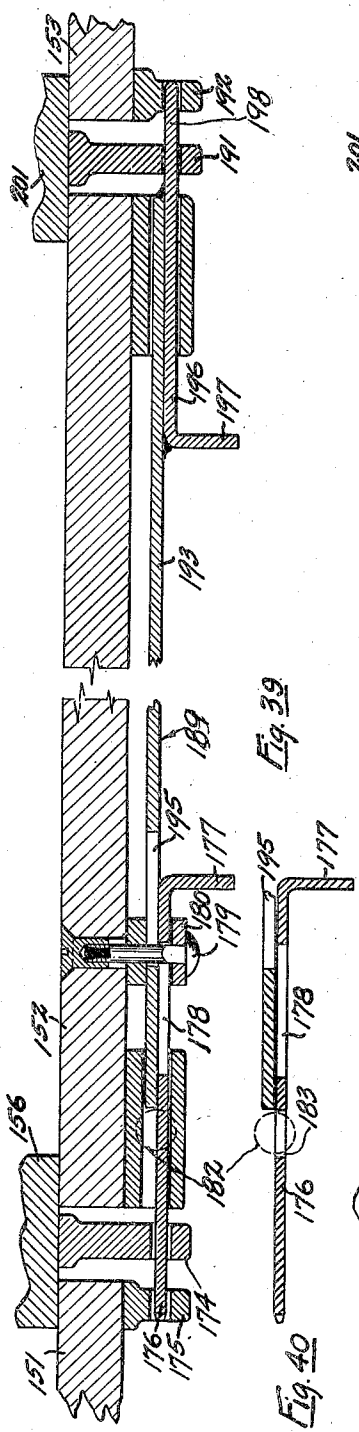


Fig. 39

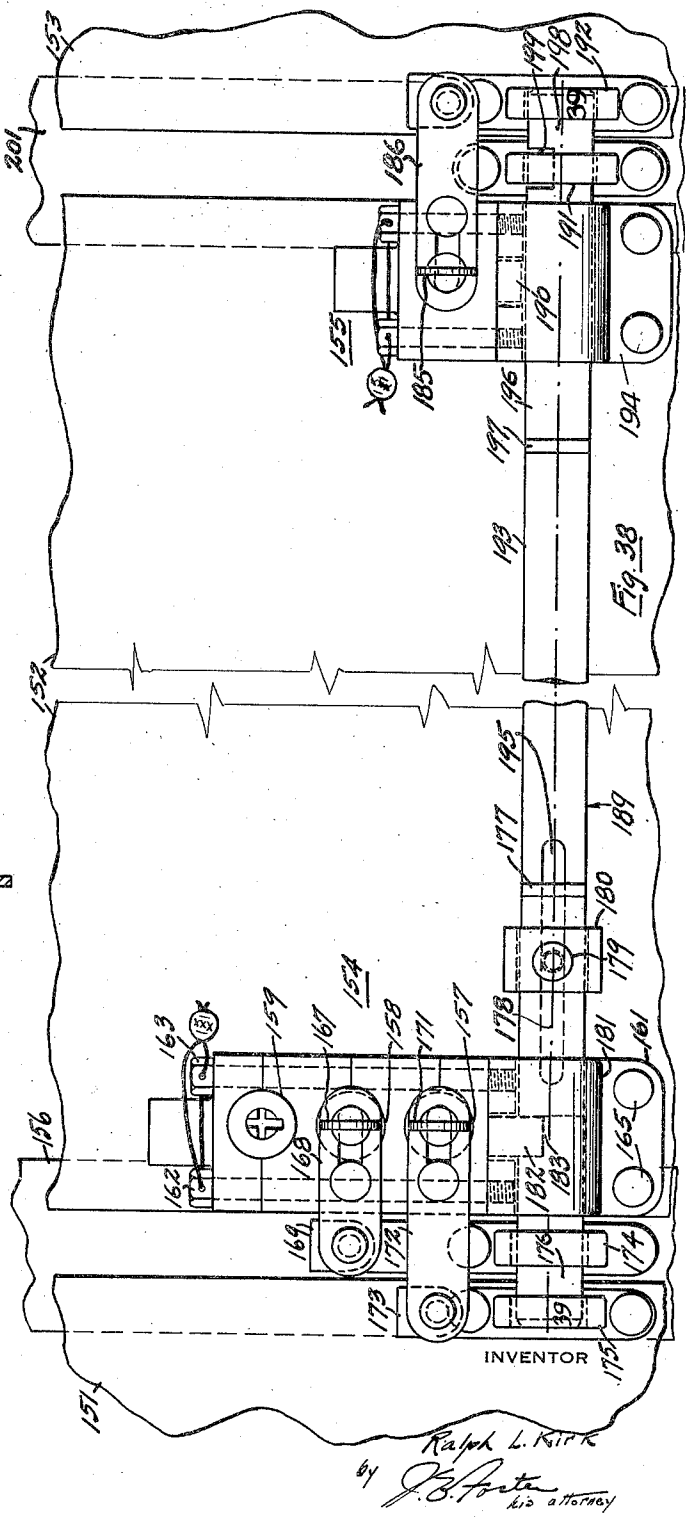


Fig. 38

Fig. 40

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Aug. 9, 1938. R. L. KIRK 2,126,333

INTERLOCK SYSTEM FOR DOORS

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Fig. 43.

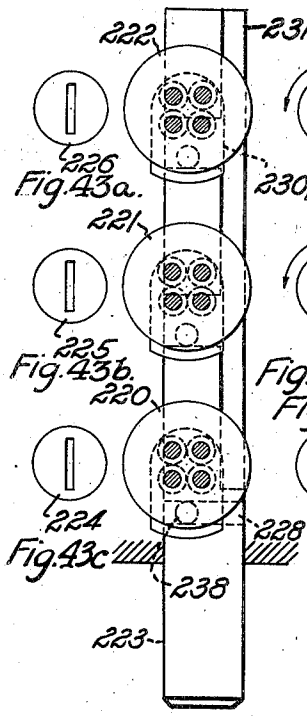


Fig. 44.

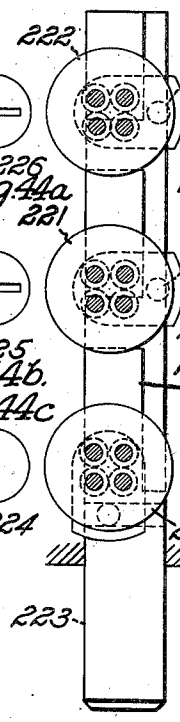


Fig. 45.

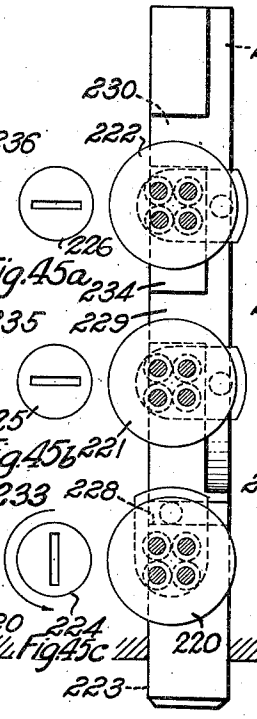


Fig. 46.

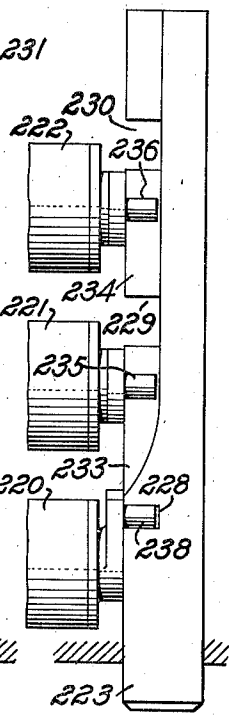


Fig. 42.

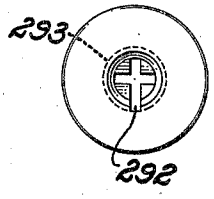
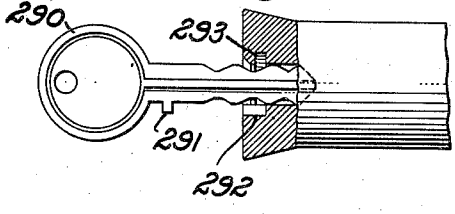


Fig. 41.



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By Potter, Pierce & Scheffler,

Attorneys.

Patented Aug. 9, 1938

2,126,333

UNITED STATES PATENT OFFICE

2,126,333

INTERLOCK SYSTEM FOR DOORS

Ralph L. Kirk, Bellevue, Pa., assignor to Railway and Industrial Engineering Company, South Greensburg, Pa., a corporation of Delaware, trustee

Application March 17, 1934, Serial No. 716,212

8 Claims. (Cl. 70—265)

This invention relates to interlock systems, and particularly to the application of interlock systems to doors of various types, such as sliding doors, hinged doors and hanging doors.

One object of my invention, therefore, is to provide a simple positive interlock system for a single door or for multiple doors, particularly doors to cells or compartments containing switching equipment in power houses, which will permit the doors to be unlocked and opened, or unlocked and removed, after the completion of a prior safety operation, such as the opening and locking-out of a circuit breaker, and which will prevent the reclosure of the circuit breaker until the doors have been relocked in closed safety positions again, so that access may not be had to the equipment behind the doors while dangerous conditions might exist or could be established due to the reclosure of the circuit breaker.

Another object of my invention is to provide an interlock system for controlling the opening and the reclosure of doors in such manner that an interlock key, released by a prior safety operation and employed to open the door or doors, shall be retained against removal until the door or doors are relocked in closed position, in order thereby to prevent the interlock key from being used to reverse the prior safety operation to restore the previous condition, until each operation in the reverse sequence is properly effected to maintain proper safety conditions.

Another object of my invention is to provide an interlock system for doors, whereby a lock for the door shall not be operable by its key until the door is in such position that operation of the lock will lock the door closed.

Another object of my invention is to provide a novel interlock method for doors, whereby the locking mechanism is so arranged that the door or doors must be moved to closed position before the locking mechanism may be operated, whereupon the doors become locked in closed position.

Another object of this invention is to provide a combination lock support and guide to cause a door to assume its proper position, when closed, to enable the lock to be operated to lock the door.

The system which I disclose and describe herein was developed primarily to provide a safety interlock system for power-house switching equipment, and for doors to compartments containing such equipment, although the application of the system is not necessarily so limited. The solutions of the problems encountered in that application, and as illustrated herein, are, of course, susceptible of general application.

Where it is necessary, for example, to work upon part of an electric circuit, or upon the equipment connected to or controlling the circuit, within a power-house or sub-station, it is desirable, as a safety precaution, to de-energize the circuit, and, if possible, to isolate the equipment to be worked upon. To establish such safety precaution, and to afford assurance of safety to those working upon the circuit or upon the equipment, the recommended procedure is to open the circuit at some appropriate switching device, such as a circuit breaker, and then to lock the switching device or circuit breaker open by a suitable locking device. When the breaker is locked open, an interlock key is released at the breaker to operate a lock at other equipment, in predetermined sequence, to provide access to such other equipment, to permit working thereon or to lock such other equipment also in predetermined safety positions.

The safety feature of the interlock system is established by providing a lock at the subsequent equipment, which will retain the interlock key against removal so long as such subsequent equipment remains accessible and unlocked.

Only when such subsequent equipment is locked and made safe against unauthorized or improper access or operation, may the interlock key be removed from the lock associated with such subsequent equipment, and used to unlock the prior equipment, such as the breaker, so that it may be reclosed again. The lock which I employ, is constructed to permit the insertion or the removal of the key in only one definite predetermined position of the lock barrel, as disclosed in my co-pending application, Serial No. 692,457, filed Oct. 6, 1933, relating to locks for interlock systems.

The prior unit in the sequence may be the operating mechanism of the breaker, and the subsequent equipment may be the contact members of the breaker, or the disconnect switches of the circuit, or a transformer in the circuit. The interlock system may be applied to control one or more sequence operations, with an interlock key released at each step to control the subsequent operation, depending upon a pre-arranged scheduled or sequence of safety operations provided for the particular equipment to be controlled.

In power houses, the various equipment which I refer hereto as subsequent equipment, is usually located in locked enclosures, such as fenced-in

areas, or completely enclosed cells or compartments, accessible through doors of one type or another. The various types of doors employed are of the sliding type, hinged type, or removable hanging type. One door or several adjacent doors may be used.

I have shown several modifications embodying my invention and the method of control as applied to doors of various types, as shown in the accompanying drawings, in which,

Figure 1 is a plan sectional view of a sliding door, and

Figure 2 is a front elevational view of the same door with a lock applied thereto;

Figure 3 is a front elevational view of a hinged door, and

Figure 4 is a side sectional view of the same door with a single lock applied thereto;

Figure 5 is a front elevational view of a hinged door with a multiple lock;

Figure 6 is a front elevational view of three adjacent cell doors with two pivoted bars arranged to be locked to lock the doors closed;

Figures 7 and 8 are, respectively, front elevational, and side sectional views of a door of the hanging type provided with a double key lock;

Figure 9 is a front elevational view of a three door arrangement provided with a single common locking bar;

Figure 10 is a front elevational view of three hinged doors, similar to those in Figure 9, but provided with a different type of common locking bar;

Figures 11 and 12 are, respectively, enlarged front elevational and end sectional views of the locking bar of Fig. 10 in its guide and the control lock therefor;

Figure 13 is a plan view of a multi-key lock assembly for a door of the hinged type;

Figure 14 is a front elevational view of the assembly of Figure 13;

Figure 15 is an end elevational view of the door in Figure 14, shown in the position where the co-operating supporting brackets engage just before the door reaches its final closed position;

Figure 16 is a side elevational view of the key-supporting bracket on the wall of the assembly in Figure 14;

Figures 17, 18 and 19 are, respectively, plan, front elevational, and side elevational views of the bracket for supporting the lock on the door in Figures 13 and 14;

Figures 20, 21 and 22 are, respectively, plan, front elevational, and side elevational views of the key-supporting bracket shown in Figures 13, 14 and 16.

Figure 23 is an enlarged plan view of a lock assembly for use in an application similar to that shown in Figure 6;

Figure 24 is a front elevational view of the lock assembly shown in Figure 23;

Figures 25, 26 and 27 are, respectively, plan, front elevational, and side elevational views of the lock-supporting bracket shown in the assembly in Figure 23;

Figures 28 and 29 are, respectively, front elevational and side elevational views of the intermediate positioning bracket shown in the assembly in Figures 23 and 24;

Figures 30, 31 and 32 are, respectively, plan, front elevational and side elevational views of the key-supporting bracket shown in the assemblies of Figures 23 and 24;

Figure 33 shows a plan and Fig. 33*a* a side edge view of the key-supporting link of the assemblies in Figures 23 and 24;

Figure 34 is an elevational view of a key for the locks, and illustrates the shape of the neck of the key by means of which it is retained in the key-supporting link in Figure 33 while permitted to have a limited sidewise motion.

Figure 35 shows a front elevational view and Fig. 35*a* an edge view of a slug filler for the keyhole slot in the key-supporting link of Figure 33, to retain the key against removal after it is inserted in the link;

Figures 36 and 37 show two other arrangements for permanently supporting a key on one of the members to be connected by the lock;

Figure 38 is a front elevational view of an interlocking assembly for mechanically connecting and interlocking three adjacent doors of the hanging and lift type;

Figure 39 is a longitudinal sectional view of the assembly in Figure 38 taken along the line **39—39**; and

Figure 40 is a sectional view of a portion of the interlocking bars in Figure 38 where they pass through the bracket for the three locks;

Figure 41 is a side view partly in section of a key barrel;

Figure 42 is an enlarged front view of a key barrel;

Figure 43 is a schematic front view of a locking bolt with one actuating cylinder and two interlock cylinders in bolt extended position;

Figures 43*a*, 43*b* and 43*c* are key hole symbols illustrating the position of the respective key barrels of Fig. 43;

Figure 44 is a similar view with the interlock key barrels in releasing position;

Figures 44*a*, 44*b* and 44*c* are key hole symbols illustrating the position of the respective key barrels of Fig. 44;

Figure 45 is a similar view with the bolt retracted, and

Figures 45*a*, 45*b* and 45*c* are key hole symbols illustrating the position of the respective key barrels of Fig. 45;

Figure 46 is a side view with the parts disposed as in Fig. 45.

As shown in Figures 1 and 2, a sliding door **1** is arranged to be moved edgewise along a wall **2** to expose an opening or passageway **3** through which access may be had to a chamber behind the door. A lock **4** is mounted on the front of the door and is provided with a long bolt **5** that extends into a recess **6** in the floor when the lock bolt is moved to its locking position with the door in closed position. The door cannot be moved from its closed position until the lock bolt **5** is withdrawn from the recess **6** in the floor. The key for the lock **4** can be inserted into the lock, and withdrawn therefrom, only when the bolt is in its full extended position. In any other position of the bolt, the key is retained against removal, as hereafter described and as shown in my co-pending application Ser. No. 692,457. Thus, if the lock is unlocked and the bolt withdrawn, the door may be moved from its closed position. If, and when, the door is moved from its closed position, the bolt cannot be extended, since it will strike the floor **7**. Consequently, the key cannot be removed from the lock so long as the door is open; and only when the door is in its closed position, can the lock be operated to extend the bolt and to release the key.

The door is thus insured against being open under improper conditions, and the interlock key is held, to prevent any chance of use, until the door is relocked.

The key for the lock may be an interlock key, released from some other device when that device is locked in a safety position, at which the interlock key may be removed. The key may also be a supervisor's key, normally held by a supervisor or other person of authority, so that access to the door may be had only by proper persons, and with the supervisor's knowledge.

In Figures 3 and 4, a hinged door 10 is provided with a lock 11, and an independent locking bar 12 slidingly mounted on the door by means of two retaining pins 13. The top of the bar 12 is bent forward to provide an operating handle 14. A notch or recess 15 in the side edge of the bar serves to receive the lock bolt 16 of the lock 11 when the bolt is extended. A recess 17 in the floor is located to receive the lower end of the locking bar 12 when the door is in closed position. Thus, only when the door is in closed position, can the locking bar 12 be lowered to position the notch 15 adjacent the lock, where the notch can receive the lock bolt 16. The key for the lock can be inserted into the key barrel of the lock, or withdrawn therefrom, only when the lock bolt is extended. Consequently, the key can be removed only when the door is locked closed, since otherwise the locking bar 12 would be in the path of the lock bolt when the bar is in raised position.

Figure 5 illustrates the application of a two-key lock 21 to a hinged door 22. The operation of lock 21 requires the presence of both keys in the respective key barrels of the lock before the lock may be operated, in either direction, to its open or to its closed position. One key, for the key barrel 24 of the lock, is permanently mounted on a link 26 permanently secured to the door 22.

In this arrangement an external supervisory key, obtained from an apparatus prior in the interlocking sequence, must be inserted in its key barrel 23 of the two-key lock 21, together with the permanent key in the other key barrel 24 of the lock, before the lock may be operated to its unlocked position to withdraw the locking bolt from a casting 25 secured to the door 22. The details of construction of the lock assembly are shown more fully in the enlarged views in Figures 13 and 14.

In Figure 6, three adjacent hinged doors, 30, 31 and 32 are arranged to be locked in their closed positions by means of two pivoted arms 33 and 34, that are arranged to be locked to each other by a two-key lock assembly 36 that is shown in greater detail in Figures 23 and 24. In this case the lock structure is mounted on one arm 33, and the permanent key is mounted on the other arm 34. Both keys must be present in the respective tumblers of the lock before the lock can be locked or unlocked.

Figure 7 shows the application of a two-key lock 40 to a door 41 of the hanging type, which may be removed from the front of an opening or passageway to an enclosure to which access is to be had. In this case, the permanent key is mounted on the door, and the lock structure is mounted on the wall, in position to be reached by the permanent key when the door is replaced in proper position, as controlled by four positioning arms 43.

In Figure 8, the hanging position assumed by the permanent key when the door is removed, is shown in dotted line.

Figure 9 shows another locking arrangement for insuring the interlocking relationship between the control lock and three pivoted doors 50, 51 and 52. A common bar 53 is pivotally supported at its ends on two pivotally mounted arms 54 and 55. The one arm 54 is provided with a circular locking plate 56 having a radial slot or recess 57, in its edge, to receive the bolt of a lock 58 when the bolt is extended to its locking position. The slot 57 in the plate 56 is so located that the bolt of the lock 58 may be extended into the slot only when the arm 54 is rotated to its lower position as indicated in solid lines in Figure 9. In that position the lock may be operated and its key withdrawn. In that position the key may also be inserted into the lock to unlock the lock, in order to withdraw the bolt and to permit the locking plate 56 to be rotated. The two arms 54 and 55 may then be rotated to their vertical positions as indicated in the broken lines, at which positions the common locking bar 53 will be elevated above the top edges of the doors, so the doors may be opened.

In the elevated position of the common blocking bar 53, the doors may be freely opened and closed to permit access to the respective compartments behind them. However, upon the completion of the operation for which access was permitted, all the doors must be moved to their closed positions before the blocking bar 53 can be relowered and locked in position to lock the doors against opening movement. Since the key cannot be removed from the lock 58 until the bolt is extended, the key will be retained in the lock until all of the doors are moved to closed position and the blocking bar lowered to the position indicated, and locked in such position. The removal of the key is therefore dependent upon positive locking of the three doors.

In Figure 10 I have illustrated another modification whereby three hinged doors may be properly controlled in an interlock system. In this case, a common blocking bar 60 is arranged to be normally located in front of the lower parts of the doors when they are to be locked against operation. When the doors are to be opened, the blocking bar 60 is arranged to be lowered below the bottom edges of the door. This construction may be employed where insufficient side space is available for the arrangement shown in Figure 9.

The details of construction of the assembly of Figure 10 may be more readily appreciated upon reference to the enlarged views in Figures 11 and 12, which illustrate how one end of the blocking bar 60 is guided in a predetermined path within a combination support and guide bracket 61. Each bracket 61 is provided with an internal slot 62 of substantially L-shape, within which the blocking bar 60 may be moved according to the condition of the lock 63 that is mounted on the blocking bar 60 adjacent the right hand guide bracket 61. The lock 63 is so mounted that the bolt can be extended into the long slot 62 only when the blocking bar 60 is in its upper position and pressed forward into the short slot against the doors and the wall 64, as shown in Figure 12. When the bolt 65 is extended into the slot 62, the bar 60 cannot be displaced from the position it occupies within the short slots in the guide bearings, and the three doors are effectively maintained closed and locked against opening. The two ends 66 of the blocking bar are bent forward at the outer side edges of the guides to limit their endwise motion between the guides.

When the door is to be opened, the interlock key is inserted in the lock 63 and it is operated to withdraw the locking bolt from the slot 62. The blocking bar 60 may then be withdrawn from the short slot at the top of the slot 62 and

lowered to the bottom of the slot 62 in both guide brackets. In this position of the blocking bar 60, the locking bolt 65 will strike against the edge 67 of the guide bracket 61 if an attempt is made to operate the lock to permit the key to be withdrawn. The key will therefore be retained against removal so long as the blocking bar 60 is in its lowermost position, and the doors will be permitted to be opened freely while the blocking bar is so lowered. Only when the blocking bar 60 is returned to its upper position, in the short slot, which can only be done when the doors are moved to their closed positions, can the lock be operated to extend the bolt and to permit the interlock key to be removed.

The various arrangements so far considered illustrate the application of the interlock system to locking doors of the three general types usually encountered, namely, the sliding door, the single hinged door and the hanging door, and also multiple doors of the hinged type. In subsequent figures 38 and 39, I shall consider the application of the interlock arrangement to a multiple door assembly of the hanging type.

Figure 13 shows one general lock arrangement and construction suitable for various applications for connecting two elements, related in manner corresponding, for example, to a door and its jamb. This construction in general may be employed, for example, for the single hinged door shown in Figure 5, or for the single lift door shown in Figure 7, and, in a general way, for the two pivoted locking arms shown in Figure 6. The lock assembly 70 of Figure 13 comprises, briefly, a two-key lock 71 secured to a supporting bracket 72 that is anchored on a door 73. A co-operating bracket 74 is mounted on the jamb 75 and supports a key 76 to fit one key barrel 77 of the two-key lock 71.

Let us assume that the normal position of the door is the locked position, as shown in Figures 13 and 14. The permanent key 76 is held against removal in the key barrel 77, of the lock. When it is desired to open the door, an external key 78 is inserted into the other key barrel 79 of the lock. Both keys 76 and 78 may be then jointly operated to actuate the locking mechanism to withdraw the locking bolt 80 of the lock from its extended position between the two co-operating castings 72 and 74. The external key 78 may be the interlock key released from some other apparatus which has been operated, as a prior step in the interlocking sequence, or it may be a supervisory key or master key held and made available only by someone in authority. The key barrel 77 of the lock is so arranged that the permanent key 76 may be withdrawn from the key barrel 77 only when the locking bolt 80 is in its withdrawn position. Consequently, the locking bolt 80 having been withdrawn from the two castings, the permanent key 76 may be removed from its key barrel 77 and the door 73 may then be freely opened.

When the key 76 is withdrawn from its key barrel 77 it will be moved outward, on, and with, its supporting link 82, to the position indicated in broken line in Figure 13, after which it may be released from the key barrel 77. The other end of the supporting link 82 is secured to a pin 83, that is mounted in two bearing sections 84 and 85 of the bracket 74 in such manner as to be limited in its movement to a fixed maximum straight longitudinal axial movement and symmetrical rotary movement about the same axis.

When the bolt 80 of the lock is withdrawn by the joint operation of the two keys 76 and 78, the interlock-key 78 is locked against removal while the key 76 is permitted to be removed. After the key 76 is removed from the lock and the door 73 is opened, the interlock key 78 cannot be removed since one key alone cannot operate the lock. The key 78 will therefore be held in the lock until the bolt may be extended, in order to permit the key to be moved back to its withdrawal position. The lock bolt cannot be moved, however, except by the joint operation of both keys. The door must therefore be moved to its closed position in order to permit the permanent key 76 to be inserted into its key barrel 77. Both keys being present in their respective key barrels, the lock may now be operated to re-extend the bolt to reconnect the two castings 72 and 74. The interlock key 78 may now be withdrawn, but the permanent key 76 will be retained against removal. The important feature of this assembly is that the door must actually be moved to its closed position before the lock can be operated to release the interlock key 78. Such compulsory restriction is imposed by provision of the permanent key and its mounting in such manner that it has a limited extent of movement within a definitely restricted path of travel, which is a path substantially co-axial with the key barrel 77, as controlled by the path of movement of the pivot pin 83 along a path parallel to the key barrel when the door is in closed position.

In order to position the door properly for locking, to take care of sagging or other displacements, the castings 72 and 74 are designed and arranged to assume a predetermined relationship when the door is moved to its closed position.

The lock-supporting casting 72 as shown in Figures 17, 18 and 19 embodies a flat rear anchor plate 90, a lateral lock-supporting plate 91, a positioning section 92, and a bolt-receiving plate 93 having a positioning tip 94 on its inner side edge. The anchor plate 90 is provided with three openings 95 through which anchoring screws may be extended to anchor the casting in position on the door. The lock-supporting plate 91 is provided with two threaded recesses 96 for receiving two threaded mounting bolts 97 to secure the lock to the lock-supporting plate 91. The plate 91 is also provided with a central opening 98 through which the lock bolt 80 may extend. The bolt-receiving plate 93 is provided with an opening 99 for receiving the lock bolt 80 in its extended position. The positioning tip 94 serves as a stop to position the casting 72 properly against the casting 74.

The key-supporting casting 74 as shown in Figures 20, 21 and 22 embodies a flat rear anchor plate 101 a curved bearing section 102 extending perpendicularly from the anchor plate 101 to provide an extended support for the two bearings 84 and 85, and a locking plate 103 provided with an opening 104 to receive the lock bolt 80 in its extended position. The rear plate 101 is provided with two openings 105 to accommodate anchoring screws or bolts, by means of which the casting bracket 74 may be secured to the jamb 75. The bearing sections 84 and 85 are provided with properly aligned openings 106 of such size as to provide an easy sliding fit for the key-supporting rod or pin 83. The bolt-receiving plate 103 is provided with converging inclined surfaces 107 and 108 on its top and bottom edges, adjacent the outer end of the plate, for preliminary rela-

tive positioning of the castings as they are moved into locking position.

The two casting brackets 72 and 74 are designed to cooperate to position each other properly to permit the lock bolt to be easily and readily extended and withdrawn for the locking and unlocking operation. As shown in Figure 13, the casting brackets should be mounted upon the elements to which they are secured in such manner that the rear surface plates 90 and 101 will be in the same plane. The two co-axially disposed openings 98 and 99 of lock bracket 72 are properly aligned and positioned to receive the lock bolt 80 when it is extended. The opening 104 in key bracket 74 is also so positioned as to be in alignment with the openings 98 and 99 to permit ready extension or withdrawal of the lock bolt 80 when the castings are in closed position. In order to properly position the two castings so that the holes will be in alignment vertically, the positioning section 92 of the lock bracket 72 is so located that its under surface 109 will be the same distance above the axis of the bolt openings 98 and 99 as the top surface 110 of the key bracket 74 is above the axis of the bolt-receiving opening 104. Consequently, when the two brackets are moved into closed position, the loop of lock bracket 72 will rest on the bolt receiving plate 103 of the key bracket 74 in such manner that the axis of the bolt receiving holes of the lock bracket 72 will be in the same horizontal plane as the bolt receiving hole of the key bracket 74.

In order to position the axis of the bolt receiving holes in the same vertical plane so that they will then be in complete and proper alignment, the outer bolt-receiving plate 93 of the lock bracket 72 is provided with the positioning tip 94 so located that it will engage the front surface 112 of the anchor plate 101 of the key bracket 74. By means of the vertical and the horizontal positionings as established by the positioning element of loop section 92 and the positioning tip 94, with respect to the surfaces 110 and 112 of the key bracket 74, all three bolt receiving openings 98, 99 and 104 are placed in exact axial alignment, so that the lock bolt 80 may be easily extended and withdrawn.

The bolt-receiving plate 93 of lock bracket 72, in addition to functioning as a positioning element by reason of its positioning tip 94, also cooperates with the lock-supporting plate 91 to provide a two-bearing support for the bolt 80 in its extended position, against any shearing force established by the bracket 74 when an attempt made to open a door while the bolt is extended.

Any sagging of the door, or tendency to sag, is taken care of, so far as the proper positioning of the lock bracket 72 is concerned, by the inclined surface 107 leading to the ultimate supporting surface 110 on the co-operating key casting 74.

The door that is shown in the drawings is a right-hand door. For a left hand door, the loop section of the lock-supporting bracket 72 must be inverted, to place the positioning section 92 at the other edge of the lock-supporting plate 91. The other bracket 74 is symmetrical with respect to its horizontal axis and may therefore be employed for right-hand and for left-hand doors.

In order to prevent tampering with the lock 71 or its removal without leaving an indication, the holding down bolts 97 are sealed by means of a sealing wire 114 and a lead seal 115 secured thereto with some appropriate identifying symbol to be impressed by a device available only to a person of authority. Thus the lock cannot be removed without leaving a visual indication, under normal conditions, and yet may be easily removed, if necessary under abnormal conditions.

In Figures 23 and 24 I have illustrated a lock assembly similar in general to the arrangement in Figures 13 and 14, except with the addition of another bracket for receiving the bolt, and with some modifications in the construction of the brackets to permit them to be properly fastened to two pivoted bars to lock the bars together, in the manner shown in Figure 6.

The lock itself, as employed in the assembly in Figures 23 and 24, is the same as those shown in Figures 13 and 14 and the various elements of the lock will therefore be referred to by the same numerals. The lock is supported on a casting 120, that is similar to the casting 72 in the assembly in Figure 13 except that the rear anchor plate 121 is provided with two holes 122 in line along the direction of the longitudinal dimension of the pivoted bar 33. The lock-supporting plate of the casting 120 is the same as in the casting 72, being provided with two threaded recesses for receiving the holding down bolts for the lock and being also provided with a large central opening to permit the lock bolt to extend through. In the present case, the loop or U-shaped section of the bracket, consisting of a lock-supporting plate 123, a positioning section 124 and a bolt-receiving plate 125, is inverted with respect to the similar part of the casting 72. The positioning section 124 in the present case engages a lower or positioning edge 126 of a bracket 127 which serves to properly position the lock-supporting bracket 120 and a co-operating key supporting bracket 128. The positioning bracket 127 is provided with a bolt receiving hole 129, the axis of which is spaced a definite distance forward from the front surface 130 of the rear or fastening web 131 of the positioning bracket 127. This horizontal distance from the axis of the bolt hole 129 to the positioning surface 130, corresponds to the horizontal distance of the axis of the lock bolt 80 from the rear surface of the anchor plate 121 of the lock-supporting casting 120. Thus, when the lock-supporting casting is moved upward to place the casting 120 into engagement with the positioning casting 127 and is pressed back to engage the positioning surface 130, the lock bolt 80 will be properly positioned in alignment with the bolt hole 129 of the positioning casting 127.

The key-supporting casting 128 supports the permanent key and is provided with a horizontally extended base plate 125 by means of which it may be properly secured to the locking bar 35. Two horizontally located holes 136 are provided for that purpose. The other parts of the key-supporting bracket 128 are the same as those described in Figures 13 and 14, except that the tapered edges at the outer end of the bolt-receiving plate are unnecessary.

In this case, the casting 128 is properly positioned by being placed in the U-shaped section of bracket 120 as a saddle, and is then pressed back against the positioning surface 130 of the positioning bracket 127. The bolt-receiving hole 138 is then in proper alignment with the bolt hole 129 of the positioning bracket in the path of movement of the lock bolt, so that the lock may be easily operated to extend or to withdraw the bolt.

The operation of the lock is controlled by the two keys in this case in the same manner as described in the arrangements in Figures 13 and 14.

The important feature of limiting the movement of the permanent key, within a definite path, is likewise retained in this assembly, thereby insuring that the locking bars are properly locked to each other before the supervisory key may be removed.

It will be obvious that the lock-supporting casting may be modified to invert the U-shaped section so that it may rest on the positioning bracket 127 in an inverted position, while the other locking bar 34 may be moved into position from underneath the lock assembly, instead of from above as required by the arrangement illustrated.

In order to retain the permanent key against removal while permitting a certain amount of lost-motion of the key with respect to its supporting link, the supporting link may be provided, as shown in Figure 33, with a key-hole slot 140. The permanent key is specially provided with a grooved collar 141 on its neck and is inserted through the round opening of the key-hole slot and then moved into the narrow portion of the slot where the grooved collar 141 will straddle the link material. A circular metal button 142, as in Figure 35, is then inserted in the round head of the key-hole slot and spotwelded in position. The permanent key is then retained in place and cannot be removed.

In Figures 36 and 37, I have shown two other arrangements for permanently securing the permanent key to one element that is to be locked.

In Figures 38 and 39 is illustrated one manner of applying an interlock assembly to three adjoining doors of the hanging lift-off type. The interlock equipment is so related to the doors and to a wall against which the doors are to rest in their closed positions, that the interlock equipment cannot be unlocked until an external key or supervisory key is inserted into the lock. Thereafter the interlocking device may be operated to disconnect the doors from each other and to unlock them from the walls so that they can be removed, to permit access to the compartments behind the doors. So long as the doors are removed from their normal hanging positions, the interlock or supervisory key is retained in the lock and cannot be removed from the lock until the doors are all first replaced in their proper closing positions in front of their various compartments, and secondly, locked to each other, and thirdly, locked to the wall in such manner as to completely prevent access to the compartments behind the doors.

As shown in Figures 38 and 39, only parts of three adjacent cell or compartment doors 151, 152 and 153 are illustrated, sufficient to show the mounting relationship of the interlock elements. The middle door 152 has mounted thereon a three-key barrel lock 154 and a single-key barrel lock 155. The three-key barrel lock 154 controls the locking function between the two doors 151 and 152, a locking function between all three doors and a wall 156, and the interlock or supervisory function of an external control key. The single-key barrel lock 155 controls the locking function between the middle door and the right hand door 153.

The three-key barrel lock 154 is similar to the two-key barrel locks already described in Figures 13 and 23, except that an additional key barrel is provided for the additional function of supervisory control. The lock 154 comprises briefly, three key barrels 157, 158, and 159, respectively, and is mounted upon a suitable casting 161 by two holding-down bolts 162 and 163, sealed by a wire seal 164 in the manner already described. The supporting bracket 161 for the lock is positively secured to the middle door 152 by rivets or the like 165.

The top key barrel 159 of the lock 154 is provided to receive the interlock or supervisory control key. The middle key barrel 158 is to receive and to be operated by a permanent key 167, permanently mounted in a link 168 that is pivotally supported on a bracket 169 anchored to the wall 156, between the two doors 151 and 152.

The bottom key barrel 157 is controlled by a permanent key 171 mounted in a link 172 pivotally supported on a bracket 173 secured to the door 151. The permanent links 168 and 172 are each pivotally supported on the brackets 169 and 173 in the manner similar to that already explained in describing the permanent key mountings in Figures 13 and 23, respectively. The two brackets 169 and 173, in addition to supporting bearings for the pivot pins for the permanent links 168 and 172, respectively, are also respectively provided with hasp sections 174 and 175 in proper alignment to receive a latching bolt 176. The bolt 176 is slidingly mounted on the middle door 152 and its movement, to an extended or to a withdrawn position, is controlled by the three-key barrel lock 154. The bolt or bar 176 is bent forwardly at its right-hand end to provide an operating handle 177. It is also provided with a longitudinal slot 178 of such length as to co-operate with an anchored stop pin 179 to determine the end or terminal positions of the latching bar 176, in its extended and its withdrawn positions. A guide bearing 180 for the bolt 176 is also held in position by the stop pin 179.

The locking bar 176 is movable in a limited horizontal path, governed by the length of slot 178, and is guided by the stop pin 179 and by a guide or bearing section 181, integral with and part of the supporting bracket 161 upon which the three-tumbler lock 154 is mounted. The opening through the guide or bearing section 181 is in direct alignment with the openings of the hasps 174 and 175 so that the latching bar 176 may be easily moved back and forth to place the two hasps and the bracket in locked, or in unlocked, relationship.

The unlocking or withdrawal movement of the blocking bar 176 is permitted or prevented, according to whether the locking bolt 182 of the three-key barrel lock 154 is extended into, or withdrawn from, a slot 183 in the top edge of the blocking bar 176. When the lock bolt 182 extends into the slot 183, the blocking bar 176 cannot be moved. When the lock bolt 182 is withdrawn from the slot 183, the blocking bar 176 can be moved. In order to operate lock 154 to withdraw the lock bolt 182, however, all three keys must be in their respective key barrels in lock 154. Normally, while the doors are locked closed, the permanent keys will be retained against removal in their respective key barrels, and the supervisory or interlock control key will not be in its key barrel. When the supervisory or interlock key is inserted, the lock may be operated to withdraw lock bolt 182 and the permanent keys 167 and 171 may then be removed from their key barrels 157 and 158. The supervisory key will be retained against removal, however, so long as the lock bolt is withdrawn.

While the lock bolt 182 is withdrawn, the blocking bar 176 may be moved to its extreme right-hand position, where the left-hand end of the

slot 178 will engage the stop pin 179 to limit the motion of the blocking bar. Such movement of the blocking bar 176 withdraws its left-hand end from the hasps 174 and 175. The door 151 is thereupon freed for removal, since the permanent key 171 may be withdrawn from blocking position.

The middle door 152 is freed for removal so far as its left-hand side is concerned, since the permanent key 167 may now be removed from the middle key barrel 158, and the blocking bar is withdrawn from the wall hasp 174. The right-hand side of the door must now be reelased, however, before that door may be removed.

The lock 155 at the right-hand side of middle door 152 is operable by a permanent key 185 mounted in a link 186 secured to the door 153. Normally, the key is held in the lock, against movement, so long as a blocking bar 189, underneath the lock bolt 190, is in the position shown, where the blocking bar 189 extends through a hasp 191 on the wall and a hasp 192 on door 153. The blocking bar is normally locked in such extended position by the extended bolt 182 of the lock 154 at the other side of the middle door 152. The blocking bar 189 extends across the middle door 152, and the left-hand end of the bar abuts against the extended bolt 182 in the position shown in Figures 38, 39 and 40. Now that lock bolt 182 has been withdrawn, however, the blocking bar 189 may be withdrawn from the hasps 191 and 192, and shifted to its extreme left-hand position, as governed by stop pin 179.

The blocking bar 189 embodies a member 193 extending between the bracket 161 for the lock 154, and a bracket 194 for the lock 155. The left-hand end of the member 193 of the blocking bar 189 is provided with a slot 195. The positioning or stop pin 179 extends through the slot and serves as a stop to determine the extreme terminal positions of the blocking bar 189. The right-hand end of the blocking bar 189 is provided with a section 196 welded thereto, to be an integral part of the blocking bar. This section 196 serves as a handle, where bent forward at one end 197, and serves also, where extended at the other end 198, as a locking bolt to extend under and through the hasps 191 and 192. This section 196 is also provided with a recess or notch 199 in its upper edge, to receive the bolt of lock 155 when the blocking bar 189 is withdrawn from the hasps 191 and 192, and moved to its extreme left-hand position.

When the three-key barrel lock 154 is unlocked and its bolt is withdrawn, as previously explained, the blocking bar 189 may be shifted over to its extreme left-hand position, to place its notch 199 underneath the bolt of lock 155. That lock may thereupon be operated, to extend its bolt into the notch 199, and to permit the permanent key 185 to be released and withdrawn from the key barrel, thereby mechanically disconnecting the two doors 152 and 153. Since the blocking bar 189 is already withdrawn from the two hasps 191 and 192, the two doors 152 and 153 are also released from the wall 201 between those doors, and they may now be removed from the wall and separated from each other.

Each door is now disconnected from each other door. The interlock control key is retained in its key barrel in lock 154 against removal, however, until all the doors are replaced and locked in position.

Due to the fact that the lock bolt of lock 155 is extended into the notch 199 in the blocking bar 189, that blocking bar will be locked against movement from its extreme left-hand position until the lock 155 is unlocked by its key 185. The blocking bar 189, in that position, extends under the bolt of lock 154, and prevents the operation of lock 154 until the lock 155 is unlocked and the blocking bar 189 re-extended to its right-hand terminal position.

The operation of unlocking the lock 155, to permit the blocking bar 189 to be shifted, requires the use of the permanent key 185 attached to the door 153, thereby mechanically tieing the doors together. The blocking bar 189 may now be shifted from underneath the bolt of lock 154, to permit that lock to be operated, when the two permanent keys 167 and 171 are inserted in their respective key barrels 158 and 157, and when the blocking bar 178 is shifted to place its recess or notch 183 under the lock bolt 182. The operation of inserting the permanent keys into their key barrels in lock 154 mechanically re-connects the doors 151 and 152 together, and also anchors the doors to the wall 156 between them.

Figs. 41 and 42 illustrate the construction employed to prevent removal of a key from its key barrel except in one position of the key. Each key 290 is provided with a guide and positioning pin 291 on the lower rib adjacent the key head. When the key is inserted into a key barrel, the pin 291 enters a gate 292 at the mouth of the barrel casing, if the key is in proper position. When the key is thus inserted and rotated, the pin 291 moves into an annular groove or channel 293 in the barrel casing so that the key cannot be withdrawn except when the pin 291 is opposite the gate 292.

In Figs. 43 to 46, is illustrated one example of a multi-cylinder controlled locking bolt. In these figures a construction using one operating cylinder and two release or interlock cylinders is disclosed but it will be obvious that more or less of the latter may be used as desired. The arrangement in Fig. 43 shows the location of the cam arms of the key barrels 220, 221 and 222 when the locking bolt 223 is moved to its full extended position and the cam arms are in locking position and the interlock keys are withdrawn from their key barrels. In this case the position of the key barrels is illustrated schematically by the key-hole symbols 224, 225 and 226 at the side of the respective locks.

In order to provide a construction whereby the pre-setting or releasing function of the key barrels 220, 221 and 222 may be readily established to permit the operating key barrel to actuate the bolt, the bolt 223 is provided with a transverse slot 228 for the cam arm of key barrel 220 and two transverse slots 229 and 230 for the cam arms of the releasing key barrels 221 and 222. In addition, a longitudinal section along the edge of the bolt is removed to provide a side passage 231 for the cam arms of the releasing key barrels 221 and 222, under certain conditions to be described.

Where the bolt is to be operated by being moved to its withdrawn position as shown in Figures 45 and 46, the proper keys are inserted into key barrels 220, 221, and 222, and the releasing key barrels 221 and 222 are respectively rotated 90° to move the cam arms out of their respective slots 229 and 230 into the side passage 231, so that the portions 233 and 234 of the bolt can be moved vertically past the cam arms 235 and 236 of the key barrels 221 and 222, respectively.

After the cam arms 235 and 236 of the two key

barrels **221** and **222** are rotated to the positions indicated in Figure 44, the operating key barrel **220** may be operated by its key to turn its cam arm **238** through an angle of 180°, as illustrated in Figure 45, as a result of which the bolt **223** is moved from its lowermost or extended position to its uppermost or withdrawn position.

In such position none of the keys can be removed. The operating key cannot be removed from the key barrel **220** until the lock is rotated back to its initial position, due to the pin **291** on the key. The keys in key barrels **221** and **222** cannot be removed while the bolt is in its upper position as in Figure 45, due to the fact that the portions **233** and **234** of the bolt **223** block the cam arms **235** and **236** in such manner as to prevent free rotation of the key barrels **221** and **222**. The keys of the releasing key barrels are thus locked against removal, as well as the operating key, while the locking bolt is in its upper or withdrawn position. When the bolt is returned to its initial lower or extended position, the keys may then be removed.

In many interlocking systems, it is desirable to provide a multi-cylinder lock structure in which one or more keys may be released for removal when the bolt is moved by the actuating lock key. The keys so released and removed may then be used to operate other locks sequentially arranged in the interlocking sequence.

To procure this feature of the lock, the convertibility feature of the cam arms on a lock is utilized, which permits a key to be removed from its lock in the extended or in the withdrawn position of the bolt, as may be desired in that particular case. In the other respective position of the bolt, the interlock key is held against removal from its lock. Thus each lock may be arranged to control its cam arm to release its key in a pre-selected position of the bolt, independently of the setting of other cylinder locks, and further, in such manner that the key slot of each cylinder lock will always be in a vertical position.

A multi-cylinder lock may thus have an actuating cylinder, a pre-setting or releasing cylinder for an interlock key from a lock prior in the interlocking sequence, and an interlock cylinder to release a key to serve as an actuating key or as a presetting key for another lock sequentially arranged in the interlocking sequence, following the multi-cylinder lock from which the interlock key is released.

It will be understood that the key retaining and interlocking arrangements shown in Figs. 41 to 46 may be used in any of the locks shown in the other figures.

Other multi-cylinder arrangements for interlocking operation of bolts may be employed, as disclosed in my copending application above referred to.

In the specification, where I refer to the joint operation of two keys, such as a permanent key and an operating key, I desire it to be understood that the lock may be operated by either key so long as both keys are present in their respective barrels.

By means of the various features and arrangements described herein, I have provided a flexible and positive system of interlocking doors of various types. My invention is not limited to the specific details of construction nor to the arrangements shown, since these may be modified without departing from the spirit and scope of the invention as set forth in the appended claims.

I claim as my invention:

1. An interlock system for doors comprising a standardized lock structure including a key operated bolt, a supporting bracket therefor to secure the lock to one member to be locked, a key adapted to operate said bolt, and a supporting bracket for the key to support the key on a second member to be locked to the first member, the two brackets being co-relatively designed, and operative when properly disposed, to prevent insertion of the key into the lock until the two members are properly positioned, and means for preventing movement of the key for insertion into its lock until the lock is in a predetermined position.

2. An interlock system for doors comprising a standardized lock structure including a key operated bolt, a supporting bracket therefor to secure the lock to one member to be locked, a key adapted to operate said bolt, and a supporting bracket for the key to support the key on a second member to be locked to the first member, the two brackets being co-relatively designed, and operative when properly disposed, to position the two members properly, when they are brought together, to enable the key to be inserted into the lock, and means for preventing movement of the key for insertion into its lock until the lock is in a predetermined position.

3. An interlock system for doors comprising a standardized lock structure including a key operated bolt, a supporting bracket therefor to secure the lock to one member to be locked, a key adapted to operate said bolt, and a supporting bracket for the key to support the key on a second member to be locked to the first member, the two brackets being co-relatively designed to position the two members properly, and the key-supporting bracket embodying means limiting the key movement to insertion into or withdrawal from the lock only when the two members are in predetermined position.

4. An interlock system for doors comprising a standardized lock structure including a key operated bolt, a supporting bracket therefor to secure the lock to one member to be locked, a key adapted to operate said bolt, and a supporting bracket for the key to support the key on a second member to be locked to the first member, the two brackets embodying means operative when properly disposed, to position the two members properly for locking when they are brought together, and the key-supporting bracket embodying a lost-motion connection with the key permitting movement of the key in a definitely limited path for insertion into or withdrawal from the lock.

5. Door locking mechanism for use in an interlocking system comprising a multi-key lock, a bracket for supporting the lock on one element to be locked, a second bracket to be secured to a second element to be locked to the first element, the two brackets embodying means that cooperate, when properly disposed, to position the two elements for proper locking, a key on the second bracket to operate the lock, and an interlock key co-operative with the key on the bracket to operate the lock, one of said keys being removable and the other retained against removal, depending upon whether the lock is in open or in closed position.

6. An interlock system for three adjacent doors of a three-cell compartment, arranged to prevent removal of the doors until an external interlock key is used, and also arranged to retain the interlock key against removal while any of said doors are removed and until all three doors are securely

relocked in position, said system comprising a key and lock combination associated with the middle door and one end door, a second key and lock combination associated with the middle door and the other end door, an interlock bar mechanically associated with the two lock combinations, a third key and lock combination associated with one of the two first-mentioned lock combinations and an anchored plate on the wall against which the doors are to rest, and a fourth lock for operation by the interlock key, the fourth lock serving, in co-operation with one of the other locks to control the interlock bar between the first and the second locks.

7. A lock for two associated members such as a door and its jam comprising a lock and a locking bolt mounted on one member and a key for the lock mounted on the other member, with means supporting the key in such manner that the key cannot be inserted to operate the lock except when the lock is in such position that it will lock the two members together when operated by the key.

8. An interlock system for doors comprising a lock structure, a supporting bracket for said lock secured to one member to be locked, a key for the lock, a supporting bracket for the key secured to a second member to be locked to said first member, the two brackets being co-relatively designed and operative when properly disposed to require proper positioning of the two members before the key can be inserted into the lock, means for preventing movement of the key for insertion into its lock until the lock is in predetermined position, said lock embodying a key cylinder for an interlock key which must cooperate with the first mentioned key to operate the lock to lock or release the door.

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